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EVALUATION OF SPRUCE BEETLE POPULATION TRENDS ON THE PAYETTE NATIONAL FOREST, IDAHO 1985 - 1988

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ABSTRACT

Permanent data collection plots were established in 1986 in seven areas on the Payette National Forest in southwestern Idaho to evaluate effects of cultural activity on and to determine trend of the current spruce beetle infestation. Three of the areas had received cultural treatment; four of the areas received no treatment.

Base information collected in 1986 was compared with similar information collected in 1988. The infestation continues in areas infested at the beginning of this evaluation, and all previously uninfested areas are currently infested. Initially, within these infestations the largest trees were preferentially attacked. As the outbreak progressed over the study period, gradually smaller trees were infested reducing the number and size of the remaining spruce. In areas having sustained beetle activity for over 3 years, up to 63 percent of the spruce had been killed. Beetle activity in two of the three areas receiving cultural treatment was substantially less than in areas receiving no treatment, even though a relatively large number of susceptible-sized trees remained. Cultural activity in all three of the stands delayed the buildup of spruce beetle populations when compared to population buildups in areas receiving no cultural treatment.

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LIFE HISTORY & POPULATION DYNAMICS

Spruce beetle (Dendroctonus rufipennis (Kirby)) infests Engelmann spruce (Picea englmannii Parry), Sitka spruce (Picea sitchensis (Bong.) Carr.), and white spruce (Picea glauca (Moench) Voss). On the Payette National Forest, Engelmann spruce is the host species.

Beetle population buildup is often initiated in windthrown trees. As populations develop, they move into green standing trees. Large diameter ($\geq$16 inches) trees are attacked first, but trees $\geq$ 8 inches may eventually be killed.

The beetle requires 1 to 3 years to complete its life cycle depending on elevation and latitude. In a 2-year life cycle (typical on the Payette National Forest), beetle flight occurs from early June through early August. The female lays eggs along a vertical egg gallery 6 to 30 cm long. The eggs hatch and the young larvae feed as a group. As they mature, they separate and feed in their own galleries. The first winter is spent in a larval stage. Through the following spring and summer the larvae grow and develop into pupae. By the second fall, callow adults emerge and overwinter in their pupal sites or exit the tree and reenter at the base of the tree around the duff line. The adults fly the following spring (Schmid & Beckwith 1975).

Spruce beetles will selectively infest large diameter ($\geq$12" diameter) trees as they provide the best environment for brood development. Generally, the larger the average spruce tree diameter in a stand, the higher the risk is for spruce beetle outbreak in the stand. As a spruce beetle infestation progresses, gradually smaller diameter trees are killed, effectively reducing the average diameter of live spruce trees in the stand.

On the Payette National Forest spruce grows on subalpine fir (Abies lasiocarpa (Hook.) Nutt.) habitat types where subalpine fir is the climax species. As the seral spruce trees are killed by bark beetles on these sites, stand composition is changed. This change reflects the succession of the stand towards its climax stage (Schmid and Hinds 1974).

HISTORY OF SPRUCE BEETLE ACTIVITY AND SUPPRESSION

The Payette National Forest has a long history of spruce beetle activity. Records from several outbreaks describe their extent and suppression measures taken to reduce spruce beetle populations. These reports seldom included followup information regarding the success or failure of the suppression efforts.

Reports indicate that a major outbreak occurred from 1947 to 1950. The outbreak was the result of abundant spruce windthrow which became infested, providing a source of spruce beetle that then attacked standing trees. The areas affected included: Fisher Creek, Fisher Creek-Brundage Divide, Granite Lake, Hazard Lake, Corral Creek, Goose Lake, Squaw Meadows, Boulder Creek, Hard Creek, and Elk Meadows. Over 2,000 infested trees were counted in a survey area covering 9,000 acres. Windthrown trees were sprayed with diclorobenzene mixed with diesel oil (1:5). Infested standing trees were sprayed from root

collar to a height 10 feet above the ground in an attempt to kill the beetles as they emerged and reentered the base of the tree to overwinter (Gibson 1949, Terrell 1950).

In 1958 to 1959, spruce beetle activity was again reported in the Fisher Creek and Granite Lake areas. Approximately 2,000 trees were killed in the Fisher Creek area (Washburn and Knopf 1959). In the Granite Lake area, ethylene dibromide was used over a 2-year period to effectively suppress the infestation (Knopf 1962).

During the mid to late 1960's, spruce beetle buildups occurred three different times. The first buildup occurred in 1965 in the Pearl Creek drainage in trees felled during road construction (Knopf 1965). In 1968, also in trees felled during road construction, a population buildup occurred in the Hazard Lake area. To suppress this population, about 700 trap trees were felled to absorb beetles and then removed. Also in 1968, a buildup occurred in windthrown and broken topped trees in Squaw Meadows, again in the Pearl Creek drainage and in Twenty Mile Creek drainage (Knopf 1969).

Finally, in 1971, spruce beetle populations developed in decked logs and windthrown trees near a timber sale in the Scribner Lake area and moved into standing trees (Knopf 1971).

The current outbreak likely began in trees windthrown in the spring of 1982 in the following areas: Railroad Saddle, Bear Creek, Middle Fork of the Weiser River, Corduroy Creek, Fisher Creek, and Granite Lake. Spruce mortality was first detected in the fall of 1985 (USDA 1985). In 1986, the Payette National Forest evaluated various available management alternatives and adopted a containment strategy to protect spruce in the Forest's roaded commercial timber base (USDA FS PNF 1986).

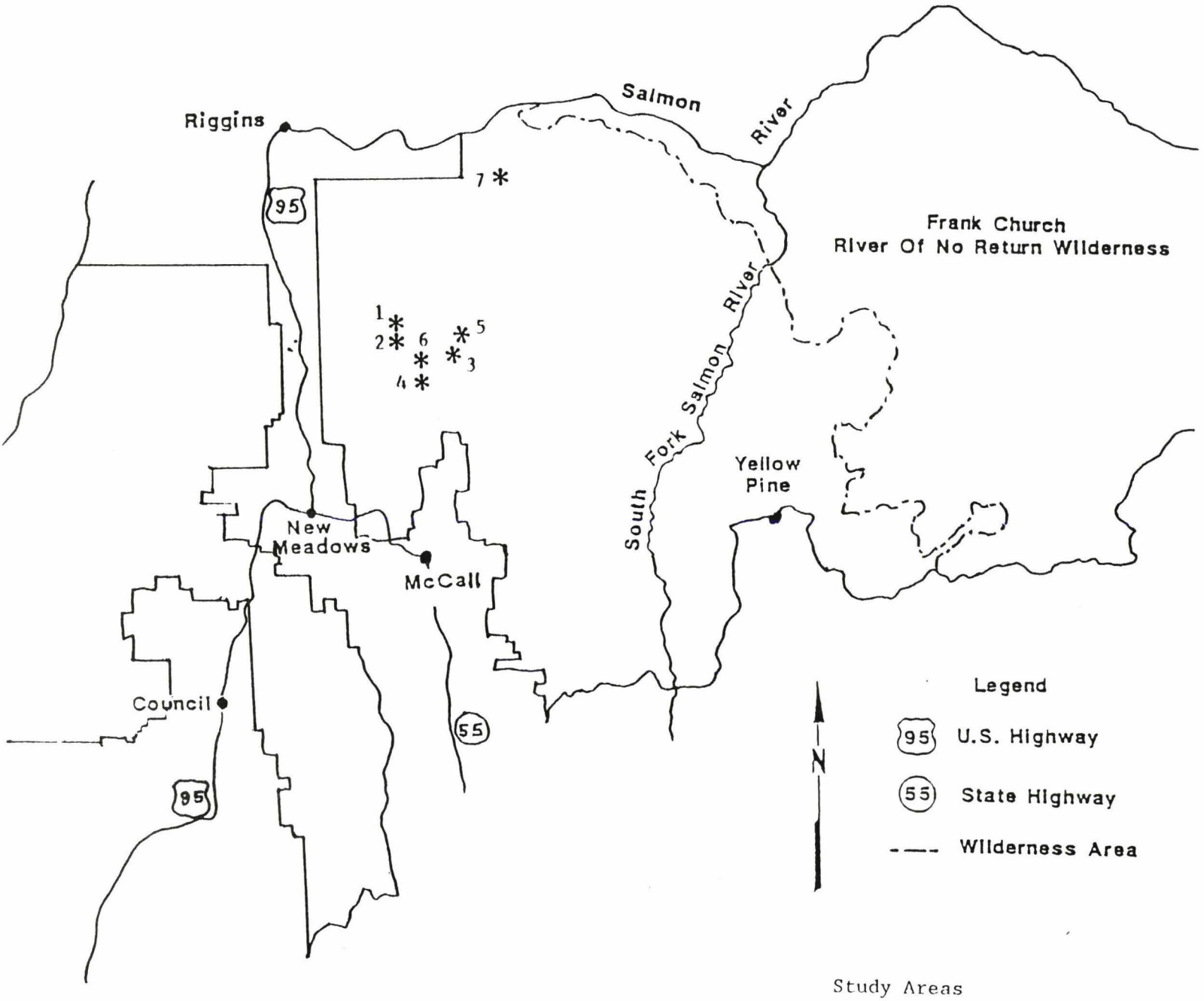
METHODS

This evaluation was designed to monitor spruce beetle-caused mortality in spruce stands which had received some type of cultural activity to reduce impact of the beetle and in stands which had received no cultural treatment.

The Payette National Forest was aerially surveyed in September 1986 to detect trees killed by the spruce beetle. Using this information, seven areas having sustained beetle activity or adjacent infested stands were selected for the evaluation: Hard Creek, Upper Fisher Creek, and Wilson Creek, where cultural activities to reduce the infestation or potential for infestation had been conducted; and Vance Creek, Jackson Creek, Little French Creek, and Marshall Lake, where no cultural activities had been conducted (Map 1). Cultural management strategy involved salvage logging of trap trees felled to absorb beetle populations as well as infested standing trees.

MAP 1.

PAYETTE NATIONAL FOREST



Study Areas

*1. Vance Creek
*2. Hard Creek
*3. Wilson Creek
*4. Upper Fisher Creek
*5. Jackson Creek
*6. Little French Creek
*7. Marshall Lake

Data were collected using the Region 4 Type 6 inventory format (USDA 1984). In the fall of 1986, permanent, 20 basal area factor, sample plots were established along transects spaced at 5 chain intervals within each evaluation area. There were two to six transects scattered across each area depending on the size and shape of the evaluation area. Data were obtained from all trees in each plot, and all were numbered with orange paint. Individual tree data collected included: species, diameter at breast height (d.b.h.), height, crown ratio, crown class, and health status. Health status involved identifying whether or not trees had been attacked by the spruce beetle. If attacked, year and success of attacks were recorded. The year of attack was identified by the stage of development of the spruce beetle. This made it possible to identify trees attacked in 1985 (the year prior to the survey). This same information was again collected during the fall of 1988. When any salvaged trees (stumps) were found, they were counted as infested and considered as being attacked in 1987.

Data collected were summarized using the INDIDS program (Bousfield et al 1985).

The stand "risk" characteristic used by Schmid and Frye (1976) was used to risk rate the surviving spruce component in each stand as follows:

Risk Category (percent)	Physiographic Location	Average Diameter of Live Spruce Above 10 inches d.b.h. (inches d.b.h.)	Basal Area (ft^2)	Proportion of Spruce in Canopy
High	Spruce on well-drained sites in creek bottoms	>16	>150	>65
Moderate	Spruce on sites with site index of 80 to 120	12-16	100-150	50-65
Low	Spruce on sites with site index of 40 to 80	<12	<100	<50

Physiographic location was not considered in our survey as each of our study areas included sites representative of each risk category. Because of the way our data were analyzed, the average diameters were calculated using all tree diameter classes 5 inches and over. Therefore, our calculated average will not be exactly compatible with the risk-rating method used. In most cases, if calculated using 10-inch and larger trees, the average diameters we use would be larger.

The "risk" is to potential infestation by spruce beetle in areas where spruce beetle is not epidemic. In an epidemic situation, the risk of infestation to smaller trees increases as the larger trees are killed.

RESULTS AND DISCUSSION

A total of 270 plots were established in the 7 drainages representing a survey of almost 1,600 acres (as determined by INDIDS) (Table 1).

Table 1. Number of plots established and the total acreage in each area surveyed.

Evaluation Area	Number of Survey Plots	Surveyed Acreage	Culturally Managed (Y/N)
Vance Creek	46	367	No
Hard Creek	31	154	Yes
Wilson Creek	30	130	Yes
Upper Fisher Creek	48	251	Yes
Jackson Creek	50	304	No
Little French Creek	40	267	No
Marshall Lake	25	125	No
Total	270	1,598	

Stand attributes prior to the 1985 beetle flight and after the 1988 beetle flight are found in Table 2. Prior to 1985, Vance Creek and Little French Creek rated as high risk areas with average diameter over 16 inches and stand basal areas over 150 ft^2. Basal area in Hard Creek was moderate but an average diameter was well over 16 inches and very high percentage of spruce were of moderate to high risk of being infested. Wilson Creek and Jackson Creek had high risk basal area but only moderate risk average diameter. Marshall Lake was borderline between high and moderate with an average diameter of 15.6. Upper Fisher Creek was a moderate risk area when both diameter and stand basal area are considered .

Table 2.--Comparison of spruce (diameters >5 in.) component attributes prior to beetle flight 1985 and after beetle flight 1988 (Culturally treated areas underlined).

Evaluation Area	Spruce Trees/Ac.		% Spruce Component		Average Diameter		Stand Basal Area		% Spruce of Mod.-High Risk	
	1985	1988	1985	1988	1985	1988	1985	1988	1985	1988
Vance Creek	104.9	24.7	37.8	18.4	22.3	15.7	153	76	86	58
Hard Creek	110.8	100.4	28.3	26.6	20.9	19.8	127	115	81	79
Wilson Creek	22.6	18.8	40.6	36.2	13.2	13.5	160	150	44	47
Upper Fisher Cr.	46.6	16.4	26.3	13.0	13.3	9.4	132	92	30	13
Jackson Creek	46.5	24.6	32.9	21.7	15.8	12.0	184	122	58	35
Little French Cr	788.4	373.6	31.2	20.1	20.8	11.7	182	111	64	30
Marshall Lake	49.0	36.2	27.5	22.5	15.6	12.1	129	95	54	37

In the four untreated study areas (Vance Creek, Jackson Creek, Little French Creek, and Marshall Lake), infestations began in 1985 or earlier. In the three culturally treated areas (Hard Creek, Wilson Creek, and Upper Fisher Creek), infestation began in 1986 or 1987 (Table 3). One possible reason for the late start of the infestation in Hard Creek, Wilson Creek, and Upper Fisher Creek was the cultural management these areas received in 1986/1987. The presence of trap trees and the salvaging of adjacent infestations probably slowed the growth of spruce beetle infestation in these areas. Additionally, because of the staggered initiation of activity, a staggered peak of activity might be expected. This did not occur. In all but two areas, Vance Creek and Little French Creek, mortality peaked in 1988.

This high level of activity in 1988 is likely due to a shift in the beetles' life cycle and the availability of drought-stressed trees. Ground evaluations in 1985 and 1986 indicated that a 2-year life cycle was typical in the area. However, in 1988 we found that a 1-year life cycle was predominant in some areas. Abnormally hot and dry conditions that persisted well into the autumn are thought to be responsible for this shift to a 1-year life cycle (Stewart 1985). Because of the change in length of the life cycle, there were likely more beetles flying and attacking trees in 1988. The 1986 brood (2-year cycle) and at least a portion of the 1987 brood (1-year cycle) matured and attacked trees in 1988.

In most cases beetles attacked largest trees in the initial stages of an infestation and gradually attacked smaller and smaller diameter trees over the course of the outbreak (Table 4). Note that beetle activity continues in all areas. The presence of large diameter spruce that have survived (unsuccessfully attacked trees) beetle attacks is consistent with past infestations reported by Schmid and Frye (1977). They reported that mortality of spruce with diameters >10 inches ranged from 65 to 99 percent.

Table 3.--Spruce mortality on study plots 1985 - 1988 (culturally treated areas are underlined).

Drainage	Number of Spruce Infested by Year as a % of Total Green Spruce Prior to 1985				Total % Spruce Killed 1985-1988
	1985	1986	1987	1988	
Vance Creek	1	13	30	19	63
Hard Creek	0	0	0	8	8
Wilson Creek	0	0	0	16	16
Upper Fisher Creek	0	2	5	52	59
Jackson Creek	2	6	11	14	43
Little French Creek	6	11	18	10	45
Marshall Lake	1	5	1	16	23

Table 4.--Chronology of spruce beetle infestation by Diameter (culturally treated areas are underlined).

Evaluation Area	Average Diameter (in inches) Older Attack (1985-1986)	Last Yr. (1987)	Current (1988)	Unsuccessful Attack	Uninfested Green Spruce
Vance Creek	28.9	26.0	20.2	17.6	15.7
Hard Creek	0.0	57.0	27.8	31.7	19.8
Wilson Creek	0.0	32.7	19.5	31.5	13.5
Upper Fisher Creek	30.2	31.6	15.6	11.4	9.4
Jackson Creek	21.7	22.0	21.8	18.9	12.0
Little French Creek	30.1	24.2	22.3	21.7	11.7
Marshall Lake	23.6	26.0	23.0	16.2	12.1

Spruce beetle activity continues in all areas; and, as indicated in Tables 2 and 4, susceptible host trees remain in all areas even following the 1988 flight. Potential for continued beetle activity, unless climatic factors change dramatically, may be predicted from numbers and sizes of susceptible host trees and stand basal area remaining in the areas. As spruce beetle has been very active in the the Vance and Little French Creek areas for over 4 years, killing many of the highly susceptible hosts, there are still some susceptible trees remaining in these two areas, particularly in Vance Creek where the average diameter is about 16 inches. Because of this risk, beetle activity will likely continue in both areas, but the number of trees killed will be low.

In Upper Fisher Creek and Jackson Creek, many of the high risk trees have been killed, and remaining trees are of relatively low risk to attack. Activity should decrease in these areas, particularly in Upper Fisher Creek.

On the other hand, the relatively small amount of total tree mortality, the large amount of high risk spruce, and the high basal area remaining in the Hard and Wilson Creek areas suggest that beetle activity will continue at a relatively high rate.

At Marshall Lake, although a relatively small amount of beetle activity has occurred, many remaining trees are of low to moderate risk of attack. Beetle activity should continue in this area at a low to moderate rate.

It appears that the Forest's beetle management strategies have increased the survival rate of large-diameter spruce in areas receiving cultural management. Total tree mortality (Table 3) in two of the three culturally treated areas (Hard Creek and Wilson Creek) was considerably less than that in the untreated areas (Vance Creek, Jackson Creek, Little French Creek, and Marshall Lake). Large numbers of spruce were killed in the culturally treated stands in the Upper Fisher Creek area. Two possible contributing causes for the large mortality figures are: 1) the area is surrounded on three sides by noncommercial areas and 2) the inadequate or improper treatment of slash and cull logs from a salvage sale conducted in 1987.

SUMMARY

In conclusion, the survey indicated that spruce beetle activity on the Payette National Forest has increased since 1985. In Vance Creek and Little French Creek drainages, spruce beetle activity is expected to continue; however, mortality rates should decline. With the high average diameter of spruce remaining in Hard Creek and the high basal area remaining in Wilson Creek, the risk of continued spruce beetle activity remains high in these areas. The Jackson Creek and Marshall Lake areas continue to have a moderate risk of activity and, with high beetle population, activity will likely continue. Upper Fisher Creek drainage is the only drainage with a low risk rating for further spruce beetle activity. With a reduction in spruce composition and average spruce diameter in all the drainages, the stands in these drainages will move closer to their successional climax stage as mature sub-alpine fir stands.

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